Easter bracelets for 5700000 years

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Easter bracelets for 5 700 000 years

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For 颖颖.

Abstract

In this brief note, we use Easter dates to weave some simple bracelets.

Easter is a moving feast, and our aim in this brief note is to construct some æsthetic summary of the dates of Easter over various periods.

1 The date of Easter

The date of Easter for a given year Y can be computed using various algorithms, for instance the one due to Gauss [1]. The version for the Julian calendar (until 1582) is the following:

$$\begin{aligned}
a &\leftarrow Y \bmod 19\\
b &\leftarrow Y \bmod 4\\
c &\leftarrow Y \bmod 7\\
M &\leftarrow 15\\
N &\leftarrow 6\\
d &\leftarrow (19a+M) \bmod 30\\
e &\leftarrow (2b+4c+6d+N) \bmod 7
\end{aligned}$$

Julian Easter then occurs on March $22+d+e$ or on April $d+e-9$. In the Julian calendar, the dates of Easter repeat in the same order after 532 years.

In the Gregorian calendar, the computation of Easter has been made more complex and the same dates of Easter repeat only after 5 700 000 years. In the

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new algorithm, M and N are only constant within a given century, and they slowly vary:

$$
\begin{aligned}
a &\leftarrow Y \bmod 19\\
b &\leftarrow Y \bmod 4\\
c &\leftarrow Y \bmod 7\\
k &\leftarrow \lfloor Y/100 \rfloor\\
p &\leftarrow \lfloor (13+8k)/25 \rfloor\\
q &\leftarrow \lfloor k/4 \rfloor\\
M &\leftarrow (15-p+k-q) \bmod 30\\
N &\leftarrow (4+k-q) \bmod 7\\
d &\leftarrow (19a+M) \bmod 30\\
e &\leftarrow (2b+4c+6d+N) \bmod 7
\end{aligned}
$$

Gregorian Easter then occurs on March $22+d+e$ or on April $d+e-9$, but there are two exceptions:

- if $d=29$ and $e=6$, the above calculation returns April 26, and it should be replaced by April 19;
- if $d=28$, $e=6$, and $(11M+11) \bmod 30 < 19$, April 25 should be replaced by April 18.

2 Color encoding of Easter dates

Our aim is to visualize the dates of Easter in 3D,[1] and with a color encoding of the dates. Our color encoding, chosen more or less randomly, is the following, for March 22 (22M) to April 25 (25A):

22M	23M	24M	25M	26M	27M	28M
29M	30M	31M	1A	2A	3A	4A
5A	6A	7A	8A	9A	10A	11A
12A	13A	14A	15A	16A	17A	18A
19A	20A	21A	22A	23A	24A	25A

[1]See [2] for a companion note with a different representation, based on the same encoding.

3 Julian Easter

We first visualize the date of Easter over a period of 19 years in the Julian calendar (figure 1). The date has a double encoding. First, we use the colors given in the previous section, and second, we use parallelepipeds whose height is small for early dates of Easter, and large for late ones. This period of 19 years is called a Metonic cycle, and after 19 years the phase of the Moon is almost the same. The phase of the Moon is one of the building blocks of Easter. However, Easter does not repeat after 19 years. It does repeat after 532 years.

In order to represent a full cycle of Easter dates in the Julian calendar, we have coiled a Metonic cycle over a torus, using 28 loops, as $532 = 19 \times 28$ (figure 2). For a more pleasing effect, we have also considered a double period (figure 3).

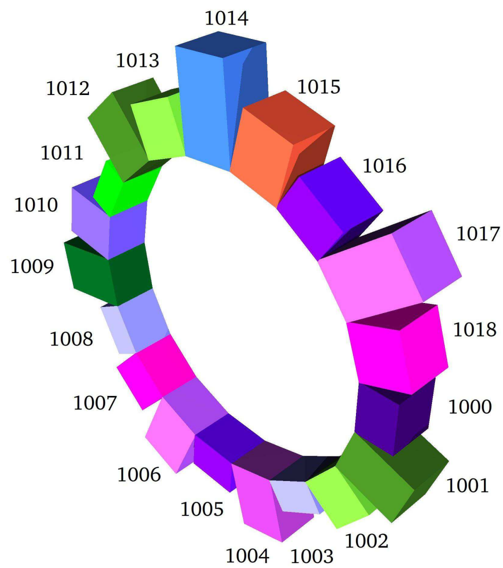

Figure 1: Julian Easter dates over a Metonic cycle.

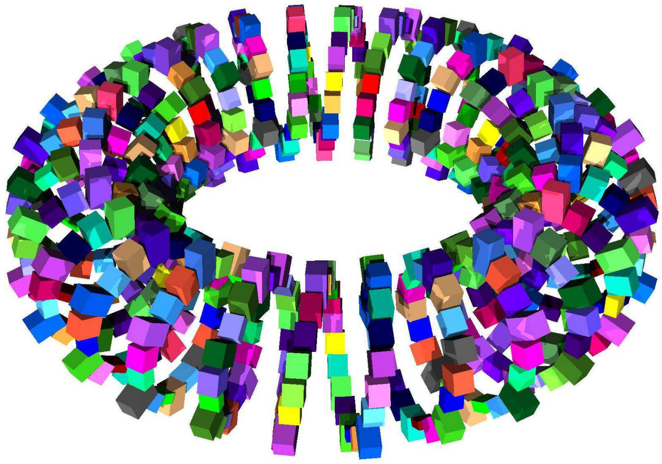

Figure 2: Julian Easter dates over a period of 532 years.

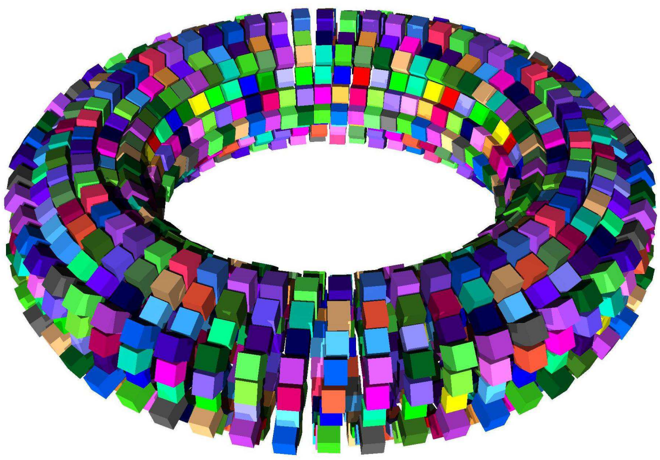

Figure 3: Julian Easter dates over a period of 1064 years.

4 Gregorian Easter

The same scheme can be applied to the date of Easter in the Gregorian calendar. However, the date of Easter only repeats after 5 700 000 years, so that we have to cram much more information in space.

We first consider a period of 200 years, with the same color encoding as above (figure 4). This ring is then coiled 300 times, covering a range of 60 000 years (figure 5). The new ring is then itself coiled 19 times to cover a range of 1 140 000 years (figure 6). Finally, this ring is coiled 5 times, reaching the final range of 5 700 000 years (figure 7).

That last representation contains 5 700 000 parallelepipeds of various colors, but due to their almost random arrangement, the overall color appears grey.

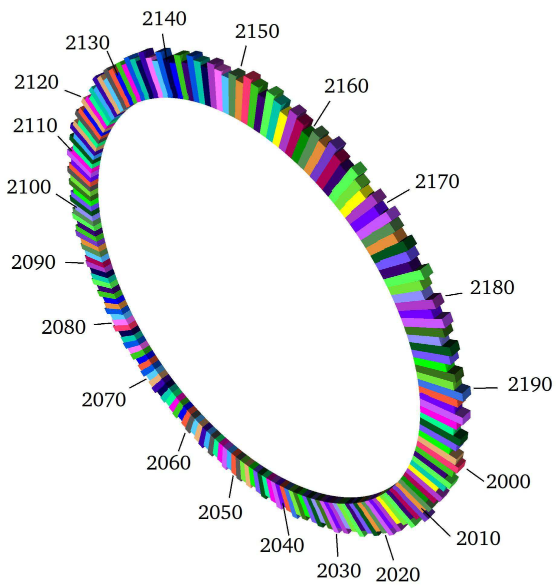

Figure 4: Gregorian Easter over a period of 200 years.

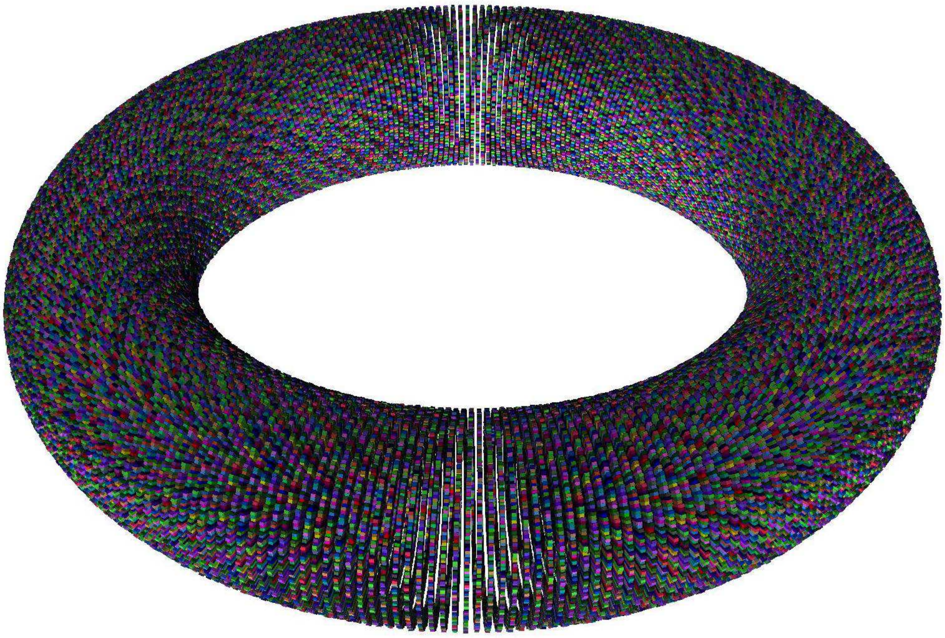

Figure 5: Gregorian Easter over a period of 60 000 years.

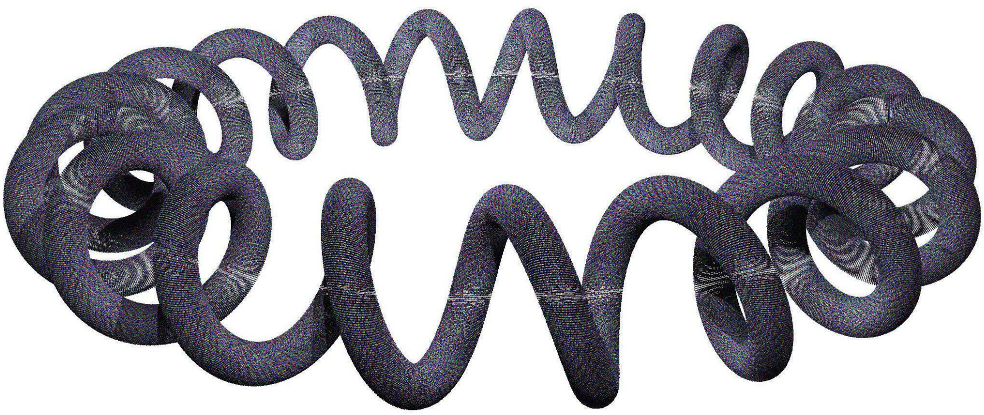

Figure 6: Gregorian Easter over a period of 1 140 000 years.

Figure 7: Gregorian Easter over a period of 5 700 000 years.

References

[1] Jean Meeus. *Astronomical algorithms*. Richmond, Virginia: Willmann-Bell, 1999. [2nd edition].

[2] Denis Roegel. Easter-based walks on a sphere. Technical report, LORIA, 2014.